B.E. INSTRUMENTATION AND ELECTRONICS ENGINEERING FOURTH YEAR SECOND SEMESTER - SUPPLEMENTERY2024

Subject : INSTRUMENTATION IN SPACE TECHNOLOGY **Time : 3hr** **Full Marks : 100**

Ensure that you clearly designate the questions you're answering by using the format: Q1.a), Q1.b), Q1.c), etc. for Question 1, Q2.a), Q2.b), etc. for Question 2, and so forth. This designation should be explicit and located directly beside each question you choose to address.

Conceptual Questions

Q1	a) What is the purpose of the Miniature Energetic Ion Composition Instrument (MEIC) onboard the Hubble Space Telescope?	5x5
Any five	b) Define "Directivity of antenna" with its mathematical expression? How does antenna radiate?	
	c) How are scintillators utilized in space technology for radiation detection and measurement?	
	d) What are the main components of a Faraday cup, and how do they function together to detect particles?	
	e) What is mixing length theory, and what does it aim to explain in the context of stellar physics?	
	f) How are sunspots formed, and what do they indicate about solar activity?What is the solar cycle, and how does it influence solar phenomena?	
	g) What instruments and methods are used to observe and measure solar flares, CMEs, and solar radio bursts?	
	h) What are the differences between sidereal time and solar time?	
	Critical Thinking Questions *(Answer based on knowledge and understanding)*	
Q2	a) What are the main types of particles that space flight particle instruments are designed to observe?	5x5
Any five	b) How does the design of a Faraday cup ensure accurate measurements of particle flux in the vacuum of space?	
	c) How do Cherenkov radiators enhance the detection of high-energy particles in space-based detectors?	
	d) What plasma properties can be determined using Langmuir probes, and how are these measurements obtained?	

	e) What is the significance of the semi-major axis in determining the size and shape of a satellite's orbit?	
	f) How do particle instruments on spacecraft protect themselves from damage caused by high-energy particles?	
	g) How are azimuth and altitude used in the horizontal coordinate system to locate celestial objects in the sky?	
	h) How do variations in sunspot numbers affect space weather and geomagnetic storms on Earth?	
	i) How the mixing length parameter is typically defined and measured?	
Analysis and Design Questions		
Q3	a) Explain the operating principle of a parabolic dish antenna. How does it focus electromagnetic waves to achieve high gain?	5x5
Any five	b) How do microchannel plates handle high-intensity particle fluxes?	
	c) How does a microstrip antenna differ from conventional wire antennas in terms of structure and operating principle?	
	d) What is the difference between Smoothing and filtering? Can simple exponential smoothing be used for forecasting?	
	e) Describe the radiation pattern of an LPDA antenna. How does it vary with frequency?	
	f) How do adaptive optics systems improve the performance of ground-based telescopes? How does a radio telescope differ from an optical telescope, and what types of astronomical phenomena can it observe?	
	g) How do space flight particle instruments calibrate their measurements to ensure accuracy in the data collected?	
	h) Analyze the trade-offs involved in selecting specific orbital parameters for a satellite mission based on mission objectives, coverage requirements, and operational constraints	
Application and Problem-Solving Questions		
Q4	a) Calculate the great-circle distance between two points on the Earth's surface: Point A (latitude 40°N, longitude 75°W) and Point B (latitude 34°N, longitude 118°W). Assume the Earth is a perfect sphere with a radius of 6371 km.	5x5
Any five	b) In a spherical triangle on a unit sphere (radius = 1), the sides a b, and c are 1.0472 radians, 1.2217 radians, and 1.3963 radians respectively. Calculate the angle A opposite side a	
	c) Calculate the magnification of a telescope with a focal length of objective lens of 1500mm and an eyepiece of focal length of 25mm.	

d) Calculate the great-circle distance between two points on the Earth's surface: Point A (latitude 40°N, longitude 75°W) and Point B (latitude 34°N, longitude 118°W). Assume the Earth is a perfect sphere with a radius of 6371 km.

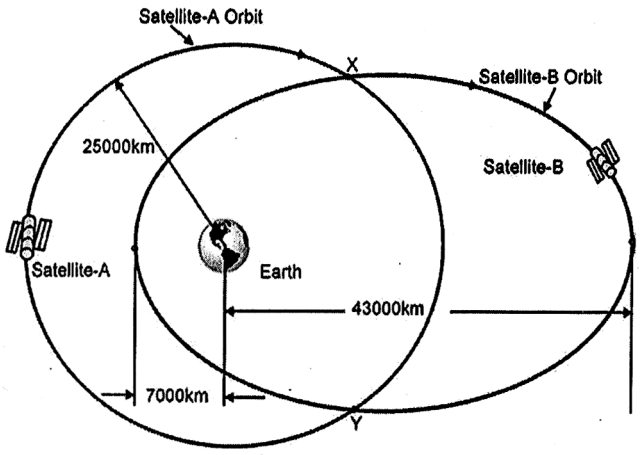
e) A rocket injects a satellite with a certain horizontal velocity from a height of 620 km from the surface of the Earth. The velocity of the satellite at a point distant 9000 km from the centre of the Earth is observed to be 8 km/s. If the direction of the satellite makes an angle of 30°with the local horizontal at that point, determine the apogee distance of the satellite orbit.(Assume that the radius of the Earth is 6380 km and $GxM_{EARTH} = 39.8 \times 10^{13}\ m^3/s^2$.)

f) Compare the light gathering power of a telescope with a 3 meter diameter mirror to that of human eye, which has a diameter of 7mm.

g) A telescope with a focal length of 1200mm is used with an eyepiece that has an apparent field of view 60 degrees. What is the actual field view in arcminutes ?

h) Calculate the orbital parameters of a hypothetical satellite orbiting Earth with the following characteristics:

- Semi-major axis: 20,000 km
- Eccentricity (e): 0.2
- Inclination: 30 degrees (i)
- Argument of Periapsis (ω): 60 degrees



i) Satellite A is orbiting Earth in a circular orbit of radius 25 000 km. Satellite B is orbiting Earth in an elliptical orbit with apogee and perigee distances of 43000 km and 7000 km respectively. Determine the velocities of the two satellites at the indicated points X and Y. (Take $\mu = 39.8 \times 10^{13}\ m^3/s^2$.)